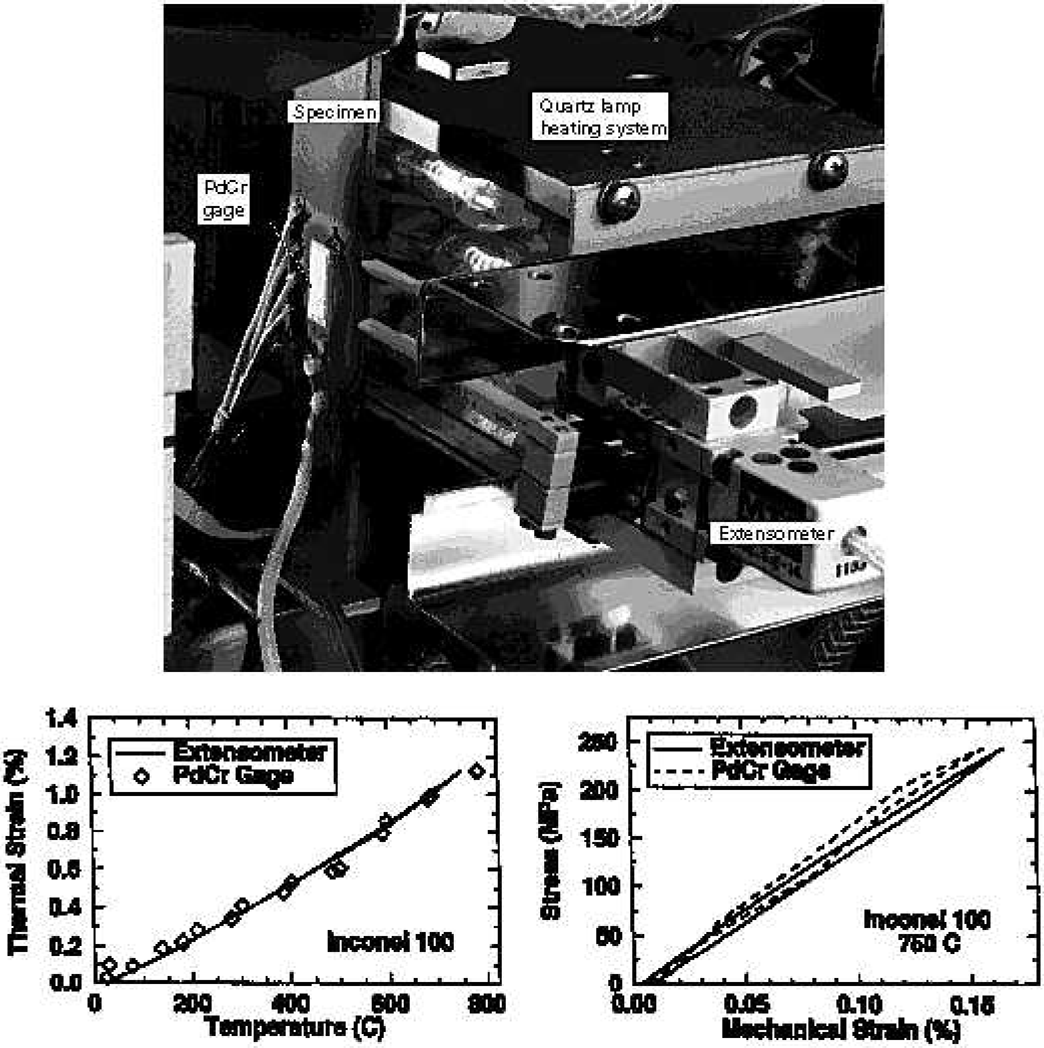
High-Temperature Extensometry and PdCr Temperature-Compensated Wire Resistance Strain Gages Compared

A detailed experimental evaluation is underway at the NASA Lewis Research Center to compare and contrast the performance of the PdCr/Pt dual-element temperature-compensated wire resistance strain gage with that of conventional high-temperature extensometry (ref. 1). The advanced PdCr gage, developed by researchers at Lewis, exhibits desirable properties and a relatively small and repeatable apparent strain to 800 °C (refs. 2 and 3). This gage represents a significant advance in technology because existing commercial resistance strain gages are not reliable for quasi-static strain measurements above ~400 °C. Various thermal and mechanical loading spectra are being applied by a high-temperature thermomechanical uniaxial testing system to evaluate the two strain-measurement systems. This is being done not only to compare and contrast the two strain sensors, but also to investigate the applicability of the PdCr strain gage to the coupon-level specimen testing environment typically employed when the high-temperature mechanical behavior of structural materials is characterized. Strain measurement capabilities to 800 °C are being investigated with a nickel-base superalloy, Inconel 100 (IN 100), substrate material and application to TMC's is being examined with the model system, SCS-6/Ti-15-3. Furthermore, two gage application techniques are being investigated in the comparison study: namely, flame-sprayed and spot welding.

The apparent strain responses of both the weldable and flame-sprayed PdCr wire strain gages were found to be cyclically repeatable on both IN 100 and SCS-6/Ti-15-3 $[0]_8$. In general, each gage exhibited some uniqueness with respect to apparent strain behavior. Gages mounted on the IN 100 specimens tended to show a repeatable apparent strain within the first few cycles, because the thermal response of IN 100 was stable. This was not the case, however, for the TMC specimens, which typically required several thermal cycles to stabilize the thermal strain response. Thus, progressive changes in the apparent strain behavior were corroborated by the extensometer, which unlike the mounted gage can distinguish quantitative changes in the material's thermal strain response. One specimen was instrumented with both a fixed and floating gage. From the difference in output of these two gages, the thermal expansion strains were calculated. These data, which are given in the figure, show excellent agreement with the values measured by the high-temperature extensometry.



Gage and extensometer output show excellent agreement under thermal and mechanical loadings. Top: PdCr gage and high-temperature extensometry on specimen in thermomechanical loading system. Bottom: Comparison of extensometer and PdCr gage.

In general, the mechanical strain measurements from the gages and extensometer on both the IN 100 (to 800 °C) and TMC (to 600 °C) were in relatively good agreement (within 10 percent) to 2000 microstrain. However, a slightly larger variation was found in the low-temperature measurements on the IN 100 specimen with the weldable gage. The weldable gage mounted on the TMC effectively failed with the initial loading. This failure was caused by a crack in the TIMETAL 21S shim at a spot-weld location. Data obtained from this gage were, therefore, erroneous since poor contact existed between the shim and the substrate composite. Subsequent to mechanical loading cycles, the specimens were subjected to thermal cycles to measure changes in the apparent strain responses. In general, the apparent strain responses of both the weldable and flame-sprayed gages were repeatable. As a final aspect of mechanical performance in the present work, the specimens are being subjected to progressively increasing mechanical loads to measure the maximum mechanical strain threshold of the gages at room temperature. Preliminary results indicate that the gages tended to lose reliable strain-measurement capabilities at approximately 4500 microstrain.

References

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2. Lei, J.-F.: A Resistance Strain Gage With Repeatable and Cancellable Apparent Strain for Use to 800 °C. NASA CR-185256, 1990.

3. Lei, J.-F.: Palladium-Chromium Static Strain Gages for High Temperatures. The 1992 NASA Langley Measurement Technology Conference Proceedings, NASA CP-3161, 1992, pp. 189-209.

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